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IS 11755 (1986): Method of test for the determination of electrical resistance and resistivity of insulating materials at elevated temperatures [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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IS : 11755 - 1986

(Reaffirmed 2001)

Indian Standard

**METHOD OF TEST FOR
DETERMINATION OF ELECTRICAL
RESISTANCE AND RESISTIVITY OF
INSULATING MATERIALS AT ELEVATED
TEMPERATURES**

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

METHOD OF TEST FOR DETERMINATION OF ELECTRICAL RESISTANCE AND RESISTIVITY OF INSULATING MATERIALS AT ELEVATED TEMPERATURES

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Indian Standard

METHOD OF TEST FOR DETERMINATION OF ELECTRICAL RESISTANCE AND RESISTIVITY OF INSULATING MATERIALS AT ELEVATED TEMPERATURES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 22 August 1986, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This Indian standard describes two test methods for determination of insulation resistance and volume resistivity of insulating materials at elevated temperatures, as under:

- a) Continuously increasing temperature (Method A), and
- b) Increasing the temperature in steps (Method B).

0.3 The measurements shall be made in accordance with IS : 3396-1979* and IS : 2259-1963†.

0.4 In the preparation of this standard, assistance has been derived from IEC Pub 345 (1971) ' Method of test for electrical resistance and resistivity of insulating materials at elevated temperatures ', issued by the International Electrotechnical Commission (IEC).

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960‡.

1. SCOPE

1.1 This standard covers two methods of tests for determination of insulation resistance and volume resistivity of insulating materials at temperatures up to, at least, 800°C.

*Methods of test for volume and surface resistivity of electrical insulating materials (*first revision*).

†Methods of test for determination of insulation resistance of solid insulating materials.

‡Rules for rounding off numerical values (*revised*).

2. PREPARATION OF SPECIMENS AND ELECTRODES

2.1 Insulation Resistance — For insulation resistance measurements, the specimens may be of any suitable size and shape and may have electrodes as given in IS : 2259-1963*. When volume resistivity is measured, the specimens shall preferably be in the form of discs, a three-electrode system shall be used, one of which is a guarded electrode. The thickness variation between any two places on the disc shall not be greater than 5 percent of the mean thickness. The specimen electrodes shall preferably be circular and consist of fired-on conducting paint or a conducting coating evaporated or metal sprayed onto the specimen faces. Gold or platinum are suitable electrode metals so as not to give rise to any change or alter original properties of base specimen. Silver shall not be used since it migrates at elevated temperatures. Thin layers of gold may lose their conductivity since the gold may agglomerate at higher temperatures. It is difficult to apply evaporated or sprayed-on electrodes to porous test specimens and the results obtained with them are of doubtful value. To minimize surface effects at the edges of the specimen (due sometimes to handling in specimen preparation), it is recommended that if no guarded electrode is used, the minimum distance from the electrodes to the specimen edge shall be 0.5 cm.

3. TEST EQUIPMENT

3.1 Resistance Measurement — The resistance between electrodes shall be measured with a suitable device having the required sensitivity and accuracy in accordance with IS : 3396-1979† (see Fig. 1).

3.2 Heating Chamber — For heating the specimen, a suitable electric oven or furnace shall be used. The construction shall be such that the specimen is subjected to a uniform temperature throughout its total volume with temperature fluctuations as small as possible. An adequate muffle shall be provided to shield the specimen from direct radiation by the heating elements. This muffle may be made of a ceramic such as aluminium oxide or equivalent. A grounded metallic shield of silver, stainless steel or equivalent metal shall also be provided within the oven. The shield shall act as a guard to prevent leakage currents between the heating circuit and the measuring circuit.

NOTE — In case of very high resistance specimens, it may be necessary to disconnect the heating element to prevent interference during the measurement.

3.3 Specimen Holder — The specimens shall be mounted securely between two electrode backing plates within the heating chamber. These backing

*Methods of test for determination of insulation resistance of solid insulating materials.

†Methods of test for volume and surface resistivity of electrical insulating materials (first revision).

plates and their respective leads should be made of a metal which is mechanically stable and resistive to oxidation. High-heat-resistant alloys such as stainless steel may also be used. Alternatively, the tests may be performed in an inert atmosphere. The backing plates shall be of sufficient thickness to prevent warping and to provide heat equalization between the specimen and the electrode backing plates. The contact faces of the plates should be equal in size to the specimen electrodes and one of the electrode backing plates should be movable so as to allow insertion and removal of the test specimen (*see* Fig. 1).

3.4 Measuring Leads — Insulated measuring leads shall be brought into the furnace through high-resistance ceramic insulators located in a cool zone and adequately guarded so as to prevent leakage current from affecting the test results.

Alternatively, the leads may be passed through holes in the top or in a wall of the furnace which shall be earthed. If stiff leads are used, they can be supported externally so as not to touch any thing but their supports. The supports will be relatively cool and thus can be made of any suitable solid insulating material.

3.5 Measurements — A measurement of current, with the supply voltage replaced by a short circuit, will indicate the magnitude of thermocouple effect.

NOTE 1 — If the material insulating the leads into the oven is subjected to heat, the insulation resistance of the lead insulation may become low enough to affect the measurements. Since the circuit is earthed between the current-measuring instrument and the voltage source (both sides of the specimen being insulated from earth), the conductance between the high potential lead and earth can be ignored if it does not constitute too large a current drain on the voltage source.

NOTE 2 — A conductance between the low potential lead and earth constitutes a shunt across the current measuring instrument. The resistance to earth of the measuring electrode must be high (10 to 100 times) as compared to the input resistance of the current-measuring instrument (which may be as much as 10^{11} ohms for the most sensitive instruments).

NOTE 3 — The leakage resistance shall be determined by a separate measurement at each temperature. Thermocouple potentials between dissimilar metals, when they are used in leads and electrode holders, can cause measurement errors.

3.6 Temperature Control — A means of temperature control shall be provided which can maintain temperature tolerances in accordance with IS : 2260-1973*. The use of two thermocouples is recommended, one in the chamber for control and a second for the direct measurement of the specimen temperature.

3.6.1 The temperature of the specimen shall be measured using a thermocouple mounted as close as possible to the specimen without causing

*Specification for preconditioning, conditioning and testing of solid electrical insulating materials (*first revision*).

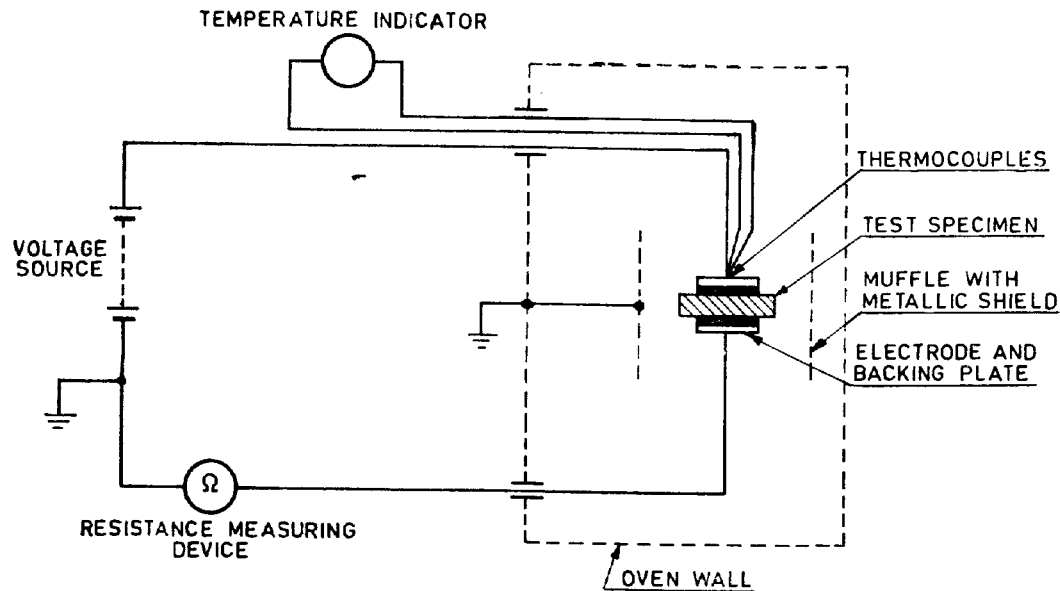


FIG. 1 TEST EQUIPMENT

electrical interaction with the measurement of resistance. For example, the thermocouple may be inserted directly into a hole extending almost to the surface of the backing plate adjacent to the specimen (see Fig. 1). The hole may be drilled from the opposite face of the plate perpendicular to the specimen or from the side of the plate parallel to the specimen surface. If the thermocouple is mounted within the electrode backing plate, the leads and the temperature-indicating instrument must be adequately insulated or the thermocouple must be disconnected or removed when measurements are made.

4. CONDITIONING

4.1 The conditioning which a specimen should receive depends upon the material being tested; it should be specified in the material specification and should be selected from among those listed in Table 1 of IS : 2260-1973*.

5. PROCEDURE

5.1 Test Method (A)

5.1.1 *Continuously Increasing Temperature (Method A)*

5.1.1.1 This method is suitable for obtaining quickly an approximate relationship between resistance and temperature of a single specimen over a wide temperature range. The method is suitable only with materials for which the effects of dielectric absorption can be neglected, or obtaining comparative results for similar materials.

NOTE — Dielectric absorption in some cases may reduce the short-time value of resistance compared to the long-time value by a factor of as much as 100.

5.1.1.2 The specimen shall be mounted tightly between the electrode backing plates, but not so tightly that the specimen is distorted while being heated. The specified voltage shall be applied to the test specimen and the temperature shall be increased at a rate depending on the thickness of the material and not higher than 5°C per minute.

5.1.3 A sufficient number of resistance measurements shall be made, as the temperature is increased, so as to define adequately the relationship between resistance and temperature.

5.2 Test Method (B)

5.2.1 *Increasing the Temperature in Steps (Method B)*

5.2.1.1 This method is suitable for obtaining the relationship between resistance and temperature of a single specimen more accurately than is

*Specification for preconditioning, conditioning and testing of solid electrical insulating materials (first revision).

possible with continuously increasing temperature. It is useful also with specimens for which dielectric absorption is a problem. The method is also convenient when more than one specimen is to be tested. The need to wait for thermal equilibrium of each specimen when several specimens are to be measured is avoided if a specimen holder is provided for each specimen or if a means is provided for transferring the specimens from the heating chamber to the specimen holder without opening the chamber.

5.2.1.2 The test specimen shall be mounted tightly between the electrode backing plates but not so tightly that the specimen is distorted while being heated. The temperature of the test specimen shall be increased as rapidly as possible from room temperature to the desired test temperature and subsequently from each test temperature step to the next.

NOTE — The test chamber should be controlled in such a manner that the temperature of the electrode backing plate does not exceed the desired test temperature.

5.2.1.3 When the temperature of the electrode backing plate is within 2°C or 1 percent (whichever is larger) of the desired test temperature, the voltage specified in the material specification shall be applied to the specimen for 1 min (or for other times as specified) and the resistance shall then be measured. When the measurement is completed, the voltage shall be removed and the high voltage, measuring and guarded (if used) electrodes shall be connected to each other (short-circuited).

5.2.1.4 A sufficient number, but not less than five, test temperatures shall be selected to define adequately the relationship between temperature and resistance over the desired range of temperatures. At the lower temperatures, the temperature increments should be relatively small, for example, 10°C. As the test temperature is increased, the temperature increments should also be increased.

NOTE — The logarithm of resistance (or resistivity) is often plotted as a function of the reciprocal absolute temperature.

5.3 Precautions

5.3.1 When the current has not stabilized in the time specified for measurement, due to dielectric absorption, it may be necessary to determine the resistance as a function of time so that the resistance value obtained at stabilization can be estimated.

5.3.2 When the resistance of the material being tested is relatively low, it may be necessary to make the measurements at a reduced voltage to avoid the effects of specimen heating.

5.3.3 For those materials in which polarization effects play a part, with concentration of ions at one or both electrodes, the results may be of doubtful value.

5.3.4 Unless the effect of thermal degradation is specifically required, the specimen shall be kept at the test temperature only long enough to attain thermal equilibrium. The maximum permissible time of exposure to the test temperature should be determined by comparing values of resistance (one minute of electrification) measured periodically over a time comparable to or longer than that expected in the tests (using an additional specimen).

5.3.5 After a series of tests at progressively higher temperatures, an additional measurement shall be made at the starting temperature to determine whether the exposure to the elevated temperatures has produced a permanent change in the specimens.

6. REPORTING OF RESULTS

6.1 Insulation Resistance — The measured value is taken as the value of insulation resistance, R .

6.2 Volume Resistivity — Volume resistivity, ρ_v , is calculated on the basis of the formula:

$$\rho_v = \frac{A}{h} \times R_v$$

where

R_v = volume resistance,

A = area of the guarded electrode, and

h = mean thickness of the specimen inside the area A .

7. TEST REPORT

7.1 The test report shall contain at least the following information:

- a) Designation or description of the material;
- b) Dimensions of the test specimen;
- c) Type of electrodes and nature of the electrode backing plates;
- d) Method of measurement of resistance after preconditioning (if any). It is also suggested that volume resistivity measurements may be carried out while test specimen is being cooled. The measurements should be made in suitable steps with 10 measurements in both increasing temperature and cooling cycle.
- e) Test voltage and time of electrification;
- f) Method of increasing the temperature, that is, method A or B;
- g) Temperature(s) at which measurements were made;
- h) Individual value(s) at each temperature; and
- j) Calculated values of volume resistivity, if required, together with the dimensions needed for the calculation.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>	<i>Definition</i>
Force	newton	N	1 N = 1 kg. m/s ²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m ²